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Measurement $PM_{2.5}$ Emission Potential from Soil Using the UC Davis Resuspension Test Chamber.

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Introduction

A new National Ambient Air Quality Standard (NAAQS) for particulate matter less than or equal to 2.5 microns in aerodynamic diameter is being considered by the United States Environmental Protection Agency (U.S. EPA). Particulate matter of this size is commonly referred to as $PM_{2.5}$ or “fine” particulate matter.
We have constructed a dust resuspension chamber to identify different soil texture to generate fugitive geological source profiles and to investigate the potential of soil to emit dust in the PM_{10} size range (Carvacho et al., 2002). Using the same protocol we also investigate $PM_{2.5}$ size range. The $PM_{2.5}$ is then separated from the dust cloud using an AIHL-design $PM_{2.5}$ cyclone and colleted on Teflon filters for gravimetric and elemental analysis. The dust generated in the chamber can be modeled by a decaying exponential function. The model parameters are related to the inherent $PM_{2.5}$ emission potential of the soil and the energy input necessary to separate the $PM_{2.5}$ from the parent material.
We have optimized the chamber operating parameters to produce results that can be related to underlying soil properties. We have tested the procedure on 44 soils spanning a range of soil textures. The chamber gives consistent results when used with the optimized operating parameters and will describe the potential of geological material to emit $PM_{2.5}$ based on the 44 soils tested. It will also compare these results to the earlier results for PM_{10}.

Materials and Methods

Since we are primarily concerned with soil particles that remain suspended in ambient air, only dried soil is used to measure the maximum potential to emit $PM_{2.5}$ Index of the soil. Approximately 1.0 g of sieved soil material with size fraction of 75 to 0 µm is placed in the dust resuspension chamber, which is then sealed. An aluminum tube of 1.0 cm diameter connects the end of the dust suspension chamber to the inside of the dust collection chamber.

A measured volume of air (3.5 lpm for 15 seconds) is forced through the soil sample at the base of the fluidizing bed. This is sufficient to suspend dust particles of ~50 µm in aerodynamic diameter, these particles are carried out of the resuspension chamber and into the collection chamber as shown in Figure 1. The particles are then collected on a 47 mm Teflon filter after passing through an AIHL-design $PM_{2.5}$ cyclone.
We sample each 15 seconds "puff" of dust for 15 minutes on a single Teflon membrane filter. We then repeat this procedure using the same sample of the soil until the soil sample is depleted of $PM_{2.5}$ material.

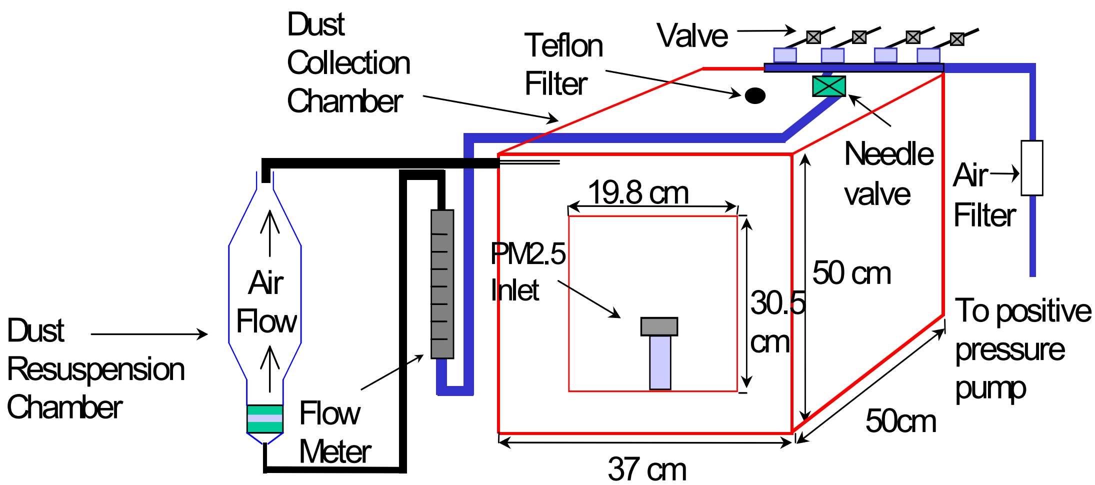

Figure1. Schematic of the C.N.L resuspension and collection chamber.

For this study, we collected 44 soil samples from agricultural fields, unpaved roads, paved roads, disturbed land areas, construction sites, and equipment staging areas in California's San Joaquin Valley. These soils spanned a wide range of texture, as shown in Figure 2. Some of the agricultural soils were replicates from different parts of the same field. Generally, the unpaved road sample was colleted from agricultural roads adjacent to the field where crop soil sample was colleted.
Both the PM_{10} and $PM_{2.5}$ Index are calculated by fitting the cumulative mass CM as a function of time t to the equation $CM = A*(1-e^{-Bt})$ as shown in Figure 3. The time parameter is the cumulative sampling time of soil suspension in the collection chamber for each filter. The parameter A is the asymptote of the decaying exponential curve and represents the PM_{10} or $PM_{2.5}$

Index. This represents the maximum amount of PM_{10} or $PM_{2.5}$ that would be released by repeated "puffs" if disaggregation did not occur.

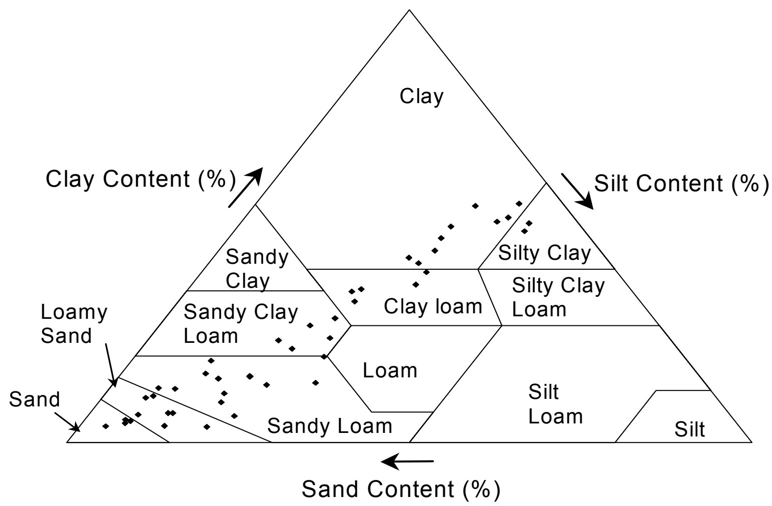

Figure2. San Joaquin Valley soil distribution in the soil texture triangle.

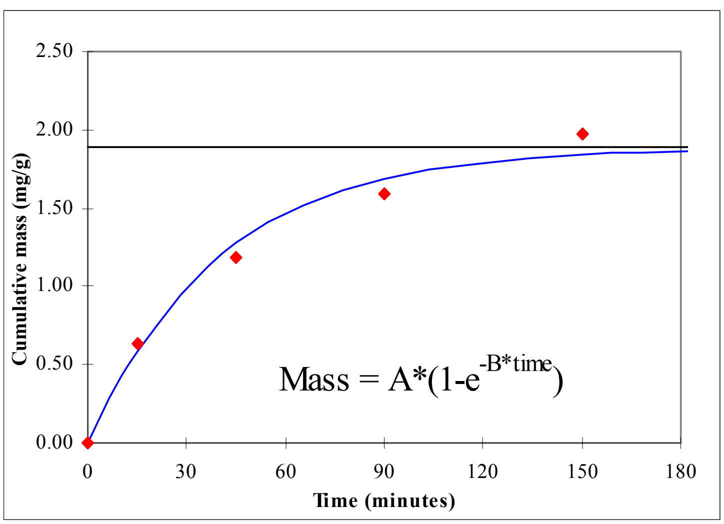

Figure 3. Curve fit for PM_{10} or $PM_{2.5}$ Index.

Results and Discussions

Figure 4. Show the relationship between $PM_{2.5}$ Index and the standard soil texture parameters sand, silt, and clay. The $PM_{2.5}$ Index is plotted for 0 to 75 µm fraction of dry-sieved soil, recall that the index is the maximum amount of $PM_{2.5}$ dust that is generated from one gram of soil material.

The sand, silt, and clay were measured by wet sieving and gravimetric pipette suspension, this represents the soil particle size distribution for completely disaggregated soils. There is a good correlation between the $PM_{2.5}$ Index with clay and sand fractions.

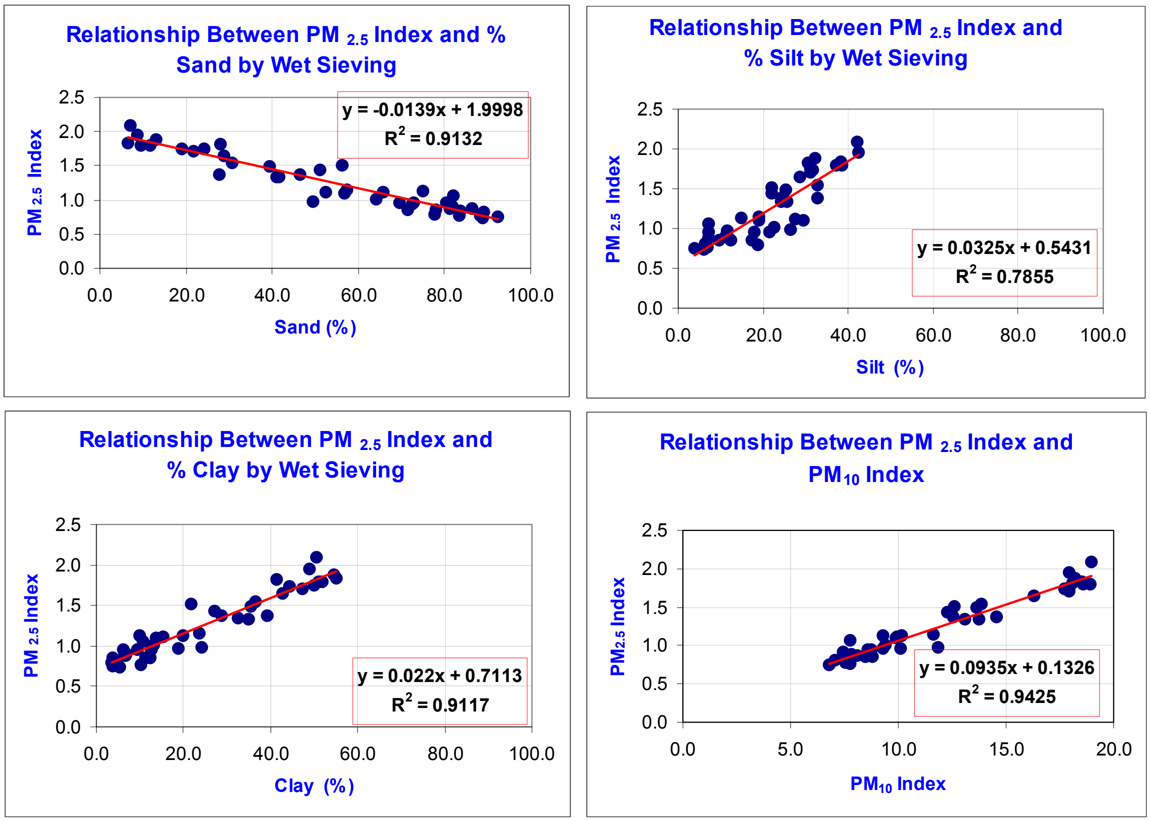

Figure 4. The relationship between the $PM_{2.5}$ Index and soil texture parameters. Also included is the relationship between the $PM_{2.5}$ Index and the PM_{10} Index.

Our results show that both the PM_{10} and $PM_{2.5}$ Index have a better correlation to the soil texture than to the dry silt content. Furthermore, the soil texture is readily available, while the dry silt content is not. For these, we expect the PM_{10} and $PM_{2.5}$ Indexes to be more useful parameters to use in emission calculations.

References

Carvacho, O.F., L.L Ashbaugh, M.S. Brown, R.G. Flocchini. 2002. Relationship Between San Joaquin Valley Soil texture and PM_{10} Emission Potential Using the UC. Davis Dust Resuspension Test Chamber. Transactions of the ASAE, Vol.44 (6) pag. 1603-1608